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A wind-wave coupled mesoscale modelling system for coastal extreme wind and wave conditions

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We are

DTU WIND (Xiaoli Larsén, Jianting Du, Mark Kelly, Andrea Hahmann, Søren Larsen, Merete Badger, Ioanna Karagali, Joakim Nielsen)

DHI (Rodolfo Bolaños, Henrik Kofoed-Hansen, Ole Petersen, Jacob T. Sørensen, Nikhil Garg)

Bergen University (Alastair Jenkins, Angus Graham)

With supports from **DONG** and **Vattenfall**

Funded by PSO ForksEL

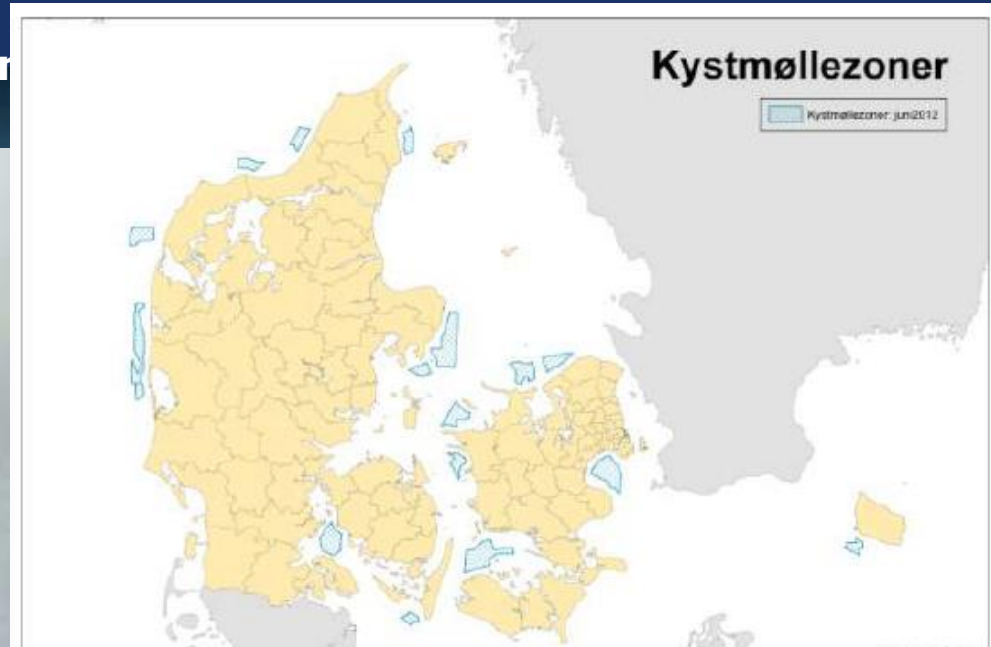
Project name: XWIWA

We aim at

- **Exploring the full potential of the different model components (atmospheric, wave and ocean model)**
- **Improving the physics and numerical descriptions for fast developing weather conditions**
- **Providing a coupled system that uses the strength of each model component for the challenging storm and coastal conditions**
- **Reducing uncertainties and therefore risk and cost for offshore, port or coastal development**

Offshore challenges

--Toward lower risk and



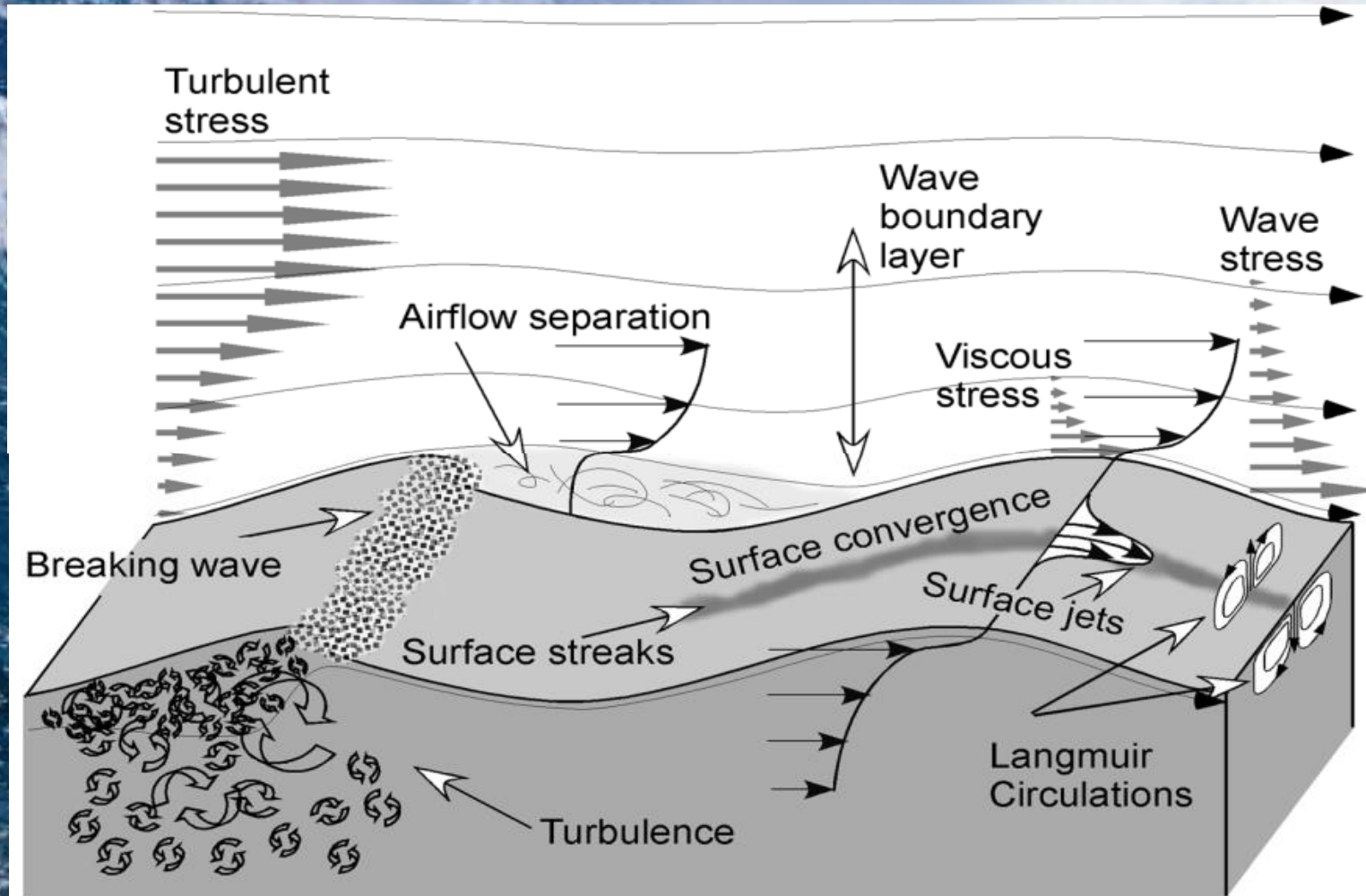
Kystnære havmøller i Danmark

Screening af havmølleplaceringer indenfor 20 km fra kysten
Juni 2012

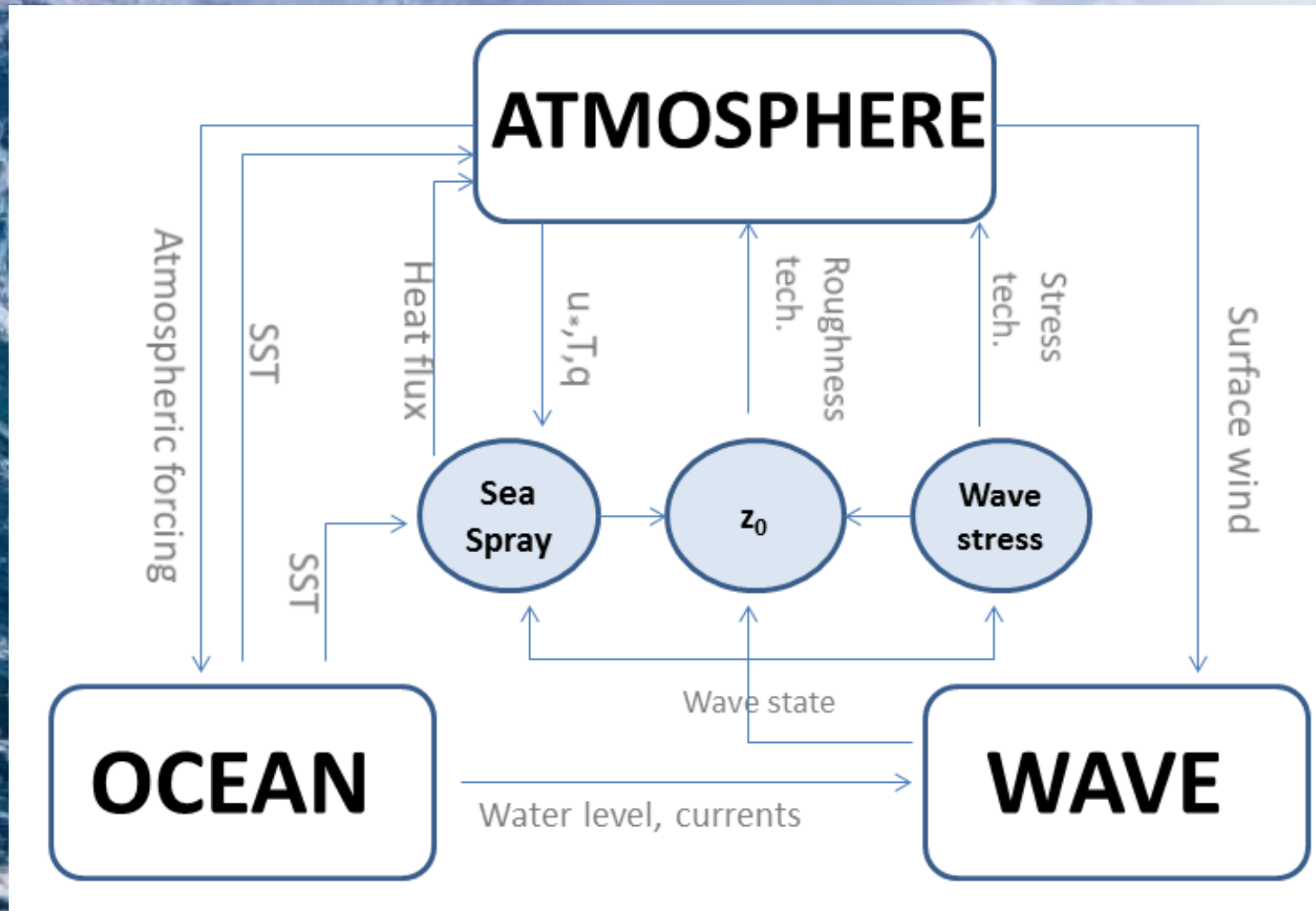
UDKAST til offentlig høring



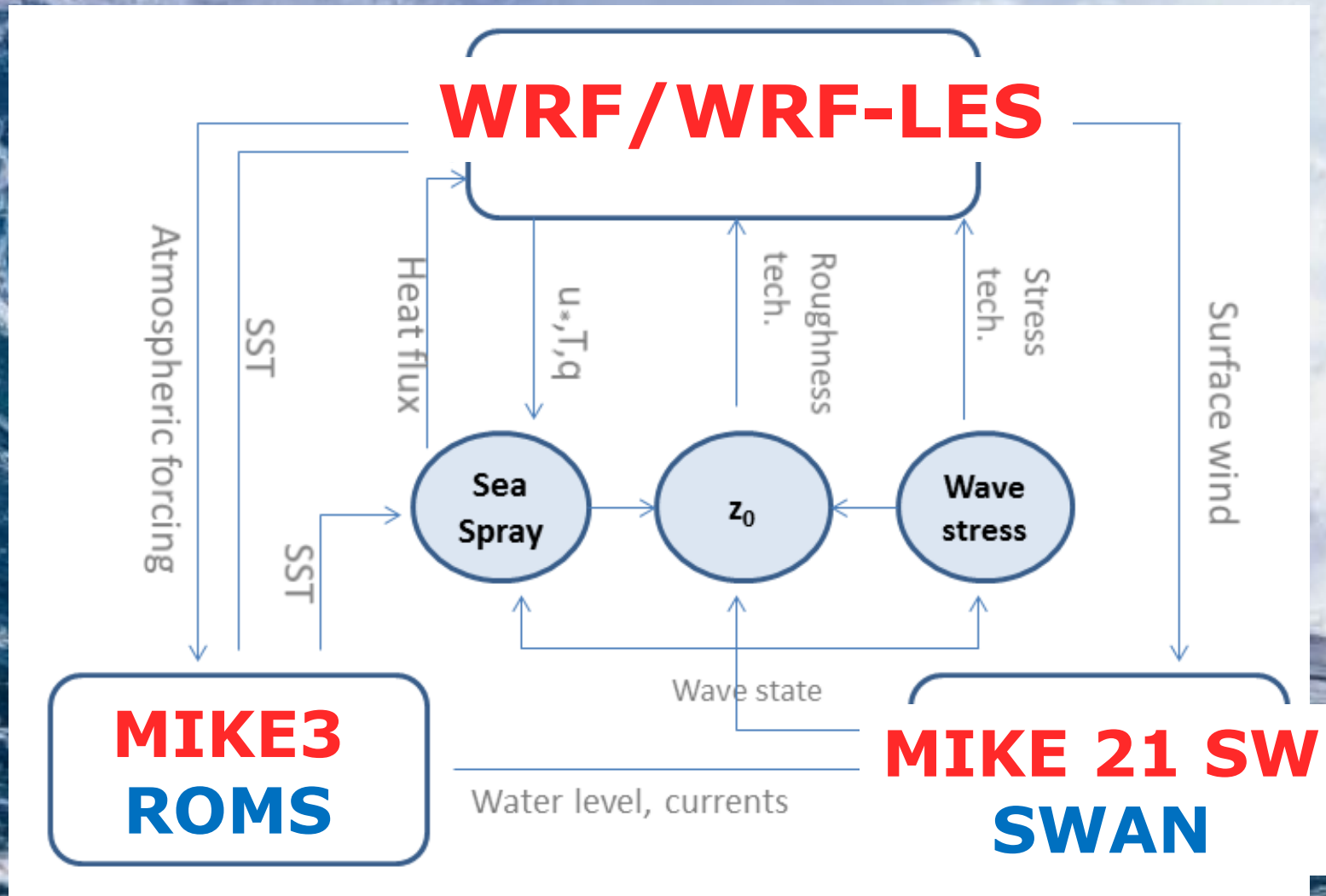
Air-sea interaction - Actions



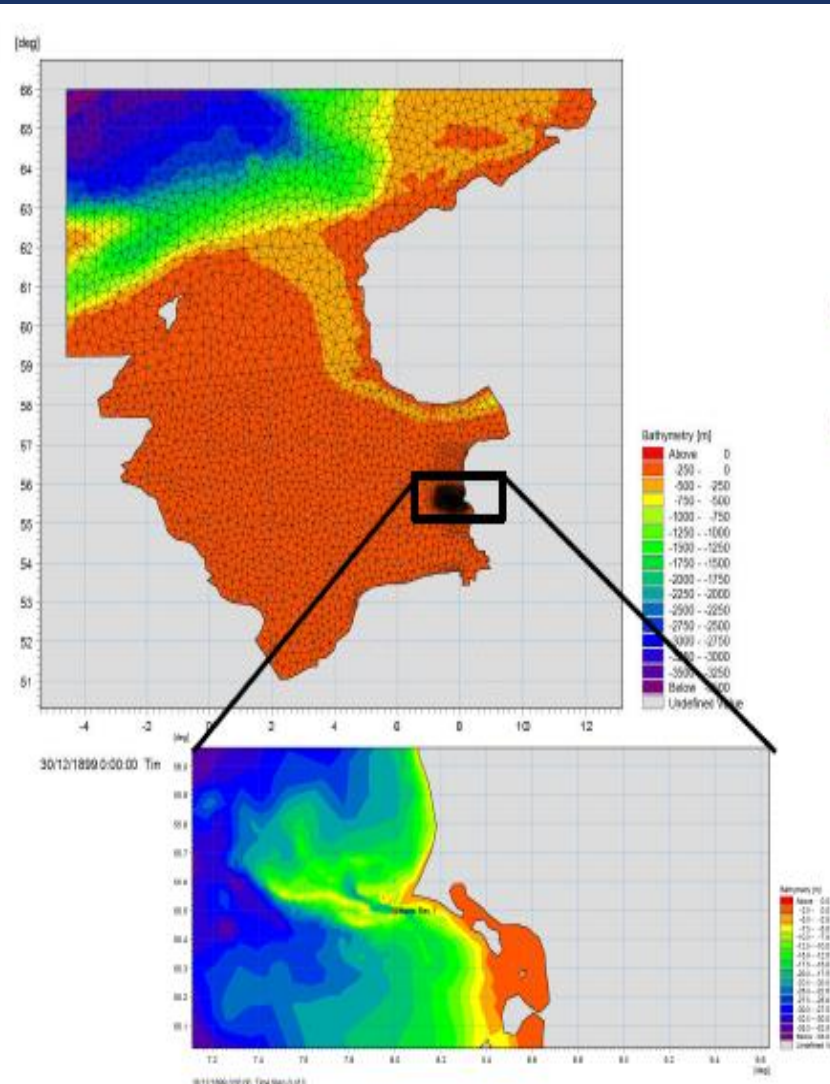
Air-sea interaction - Actions



Air-sea interaction - Actions



MIKE functions and strength



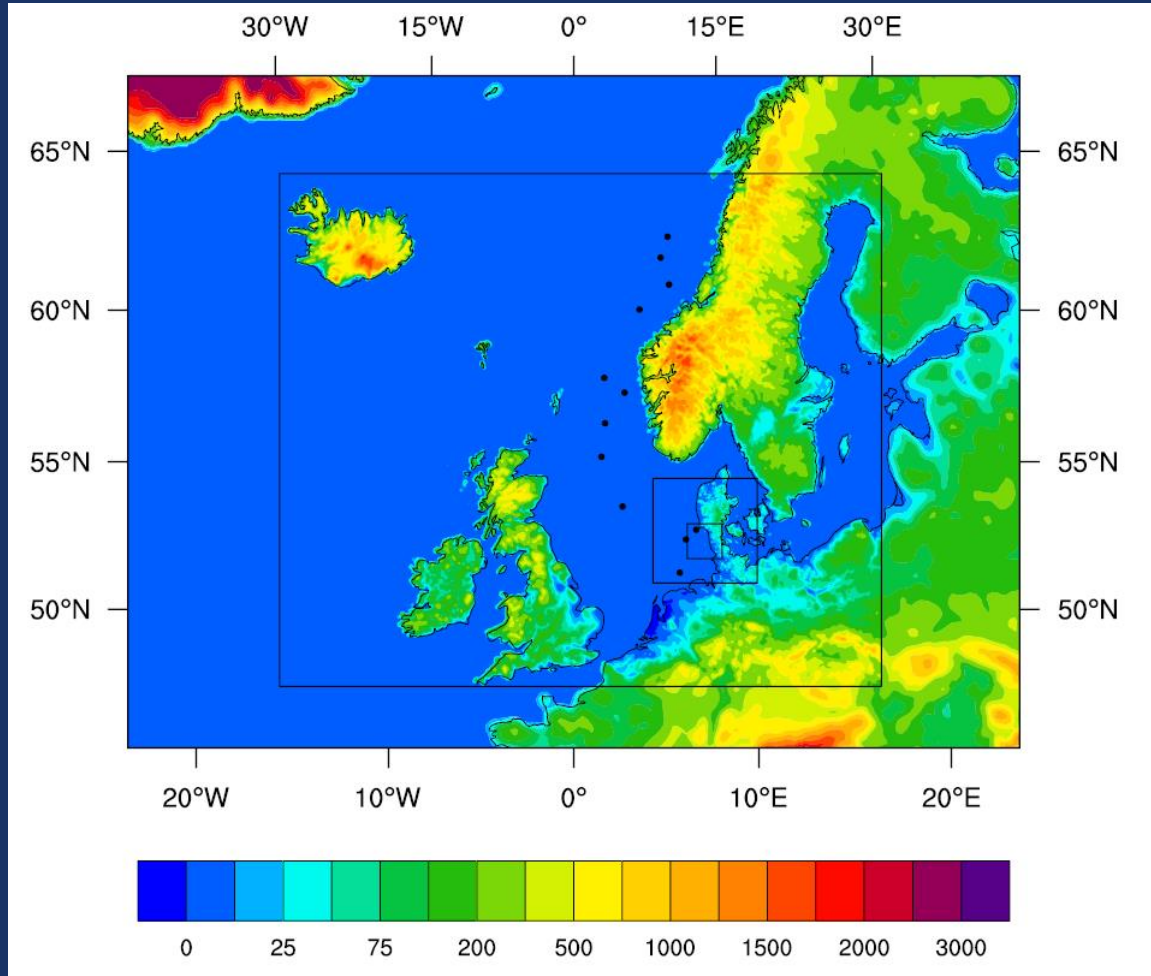
Meso (10km → 10m)

- Deterministic, phase-resolving wave models
- Wave transformation
- Propagation of errors?

Micro (100m → 0.1m)

- CFD
- Highly non-linear effects

WRF functions and strength



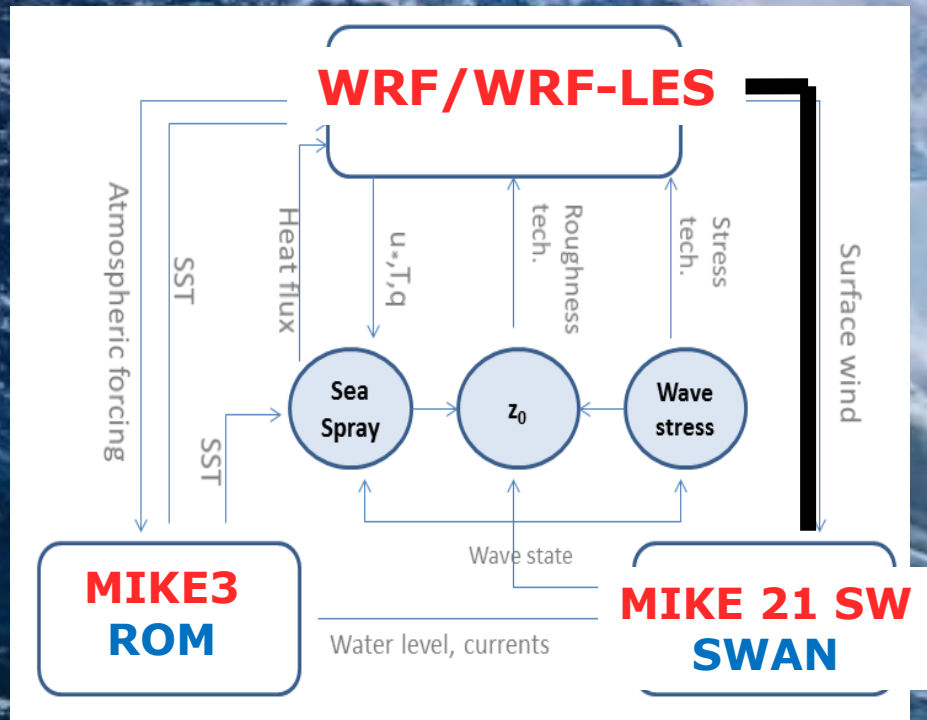
WRF model domain

18 km – 6 km – 2 km

– 666.7 m – 222.3 m ~ 100 m

(WRF-LES)

Actions



We have been examining coupling techniques:

**One-way offline, two-way offline,
two-way online**

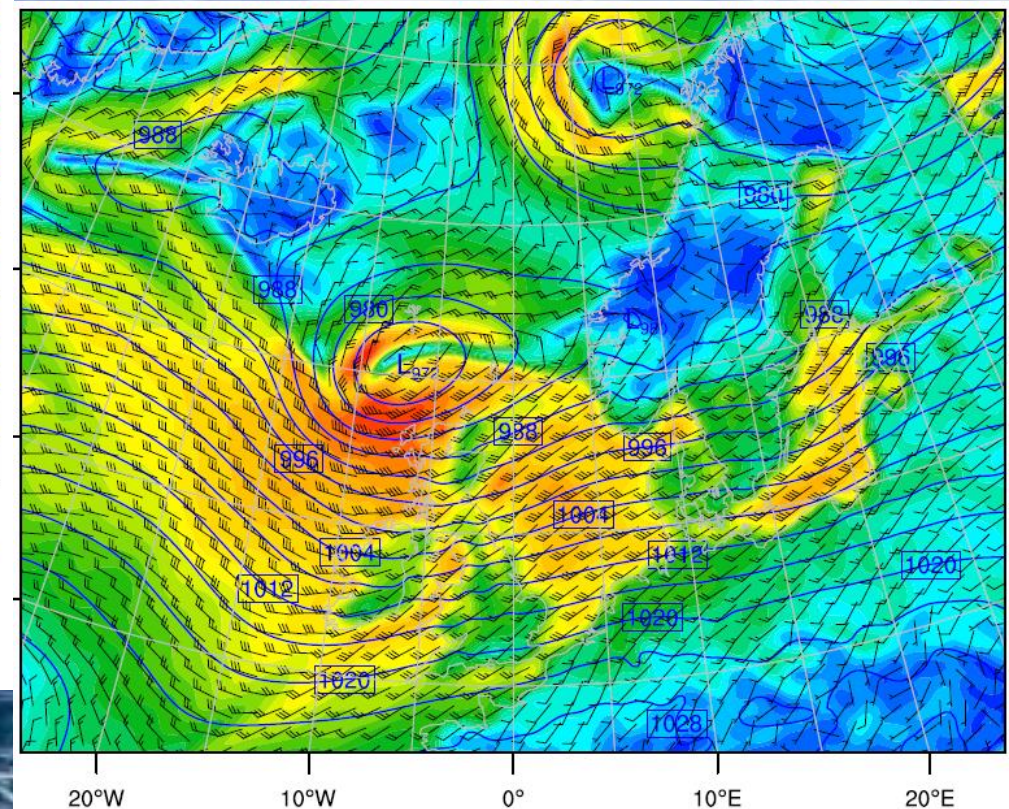
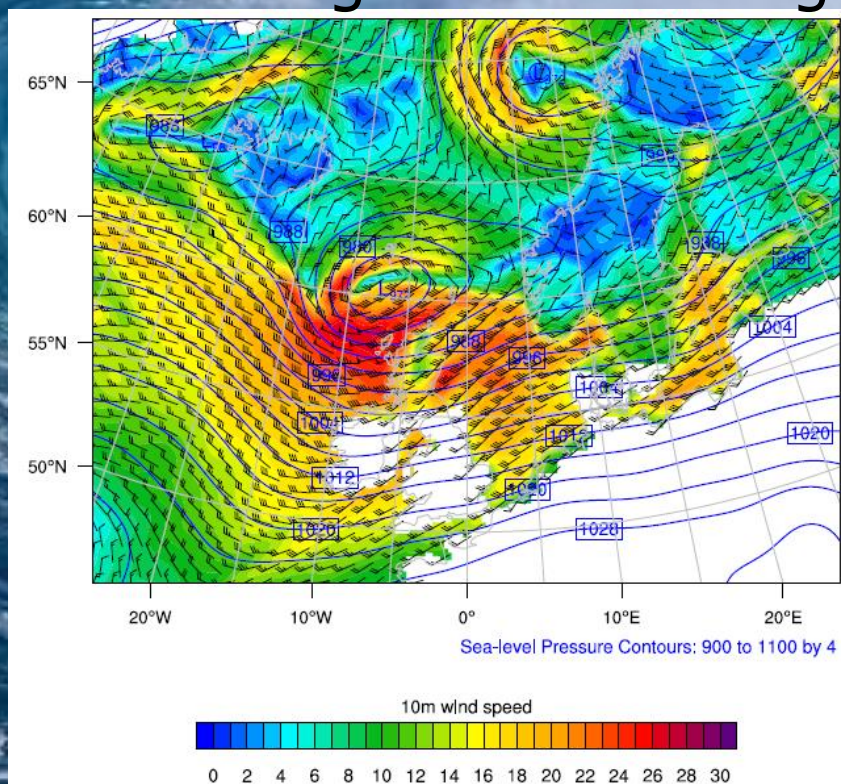
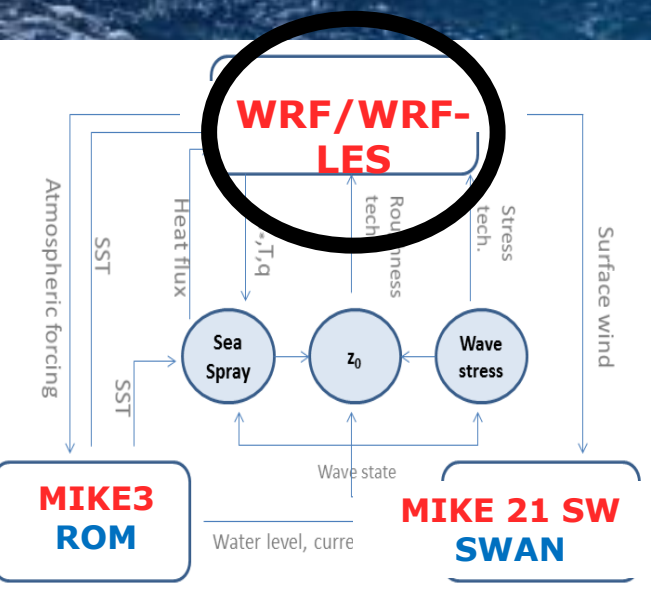
The results on the wind outputs could be very different!

Actions

When modeling a storm, we examine
Domain, initial time
to best reserve the large scale storm structure

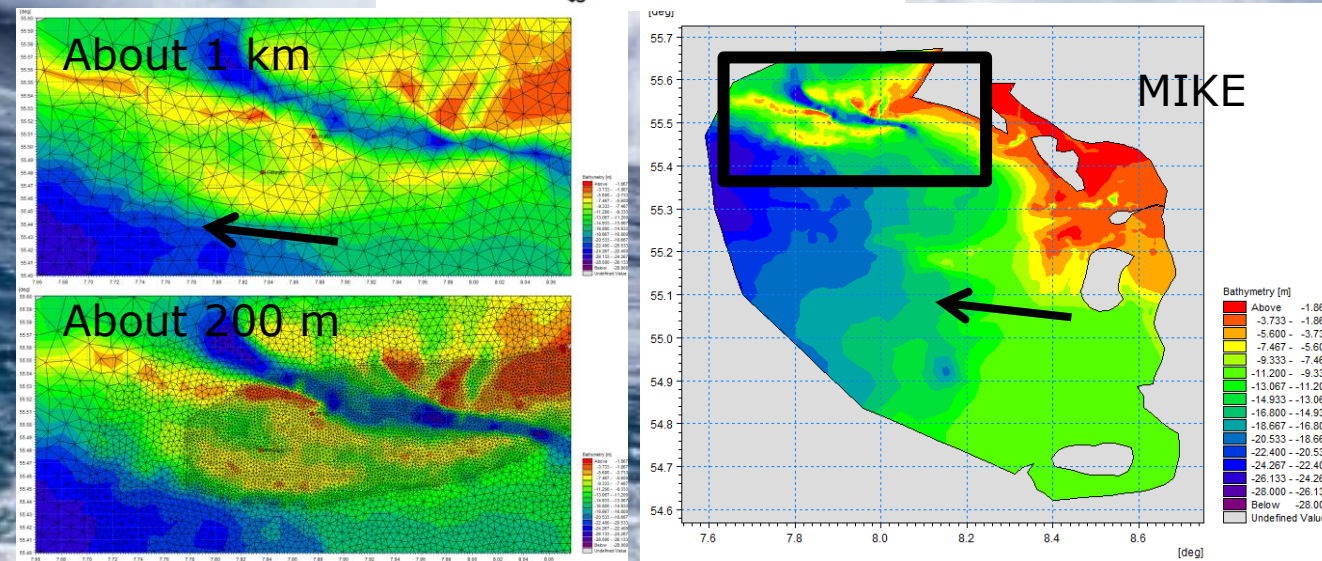
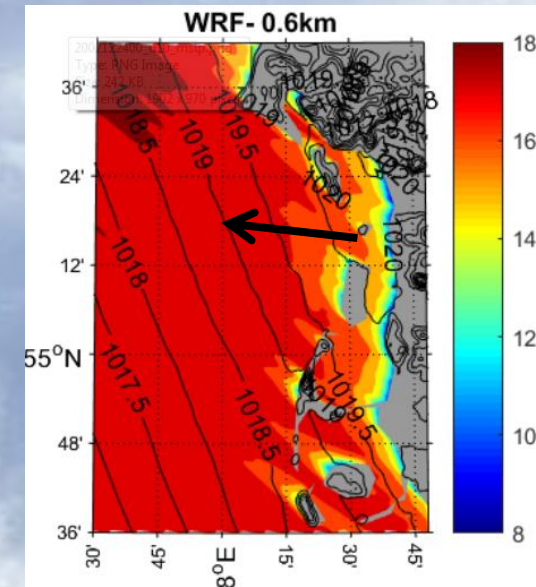
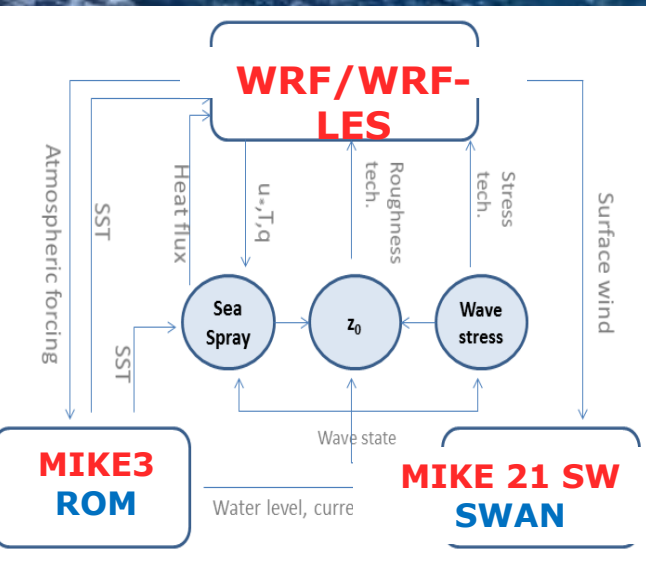
CFSR large scale forcing

WRF outer domain



Actions

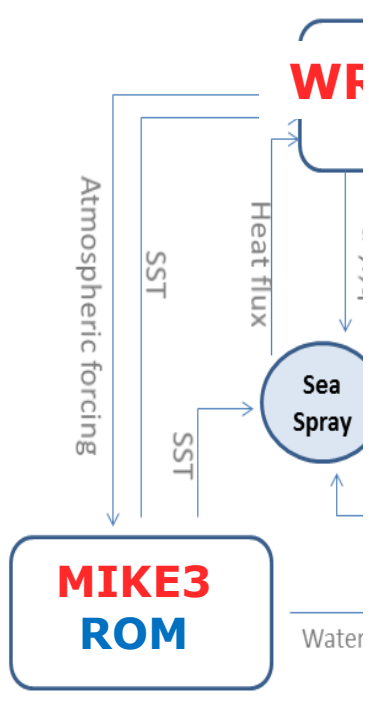
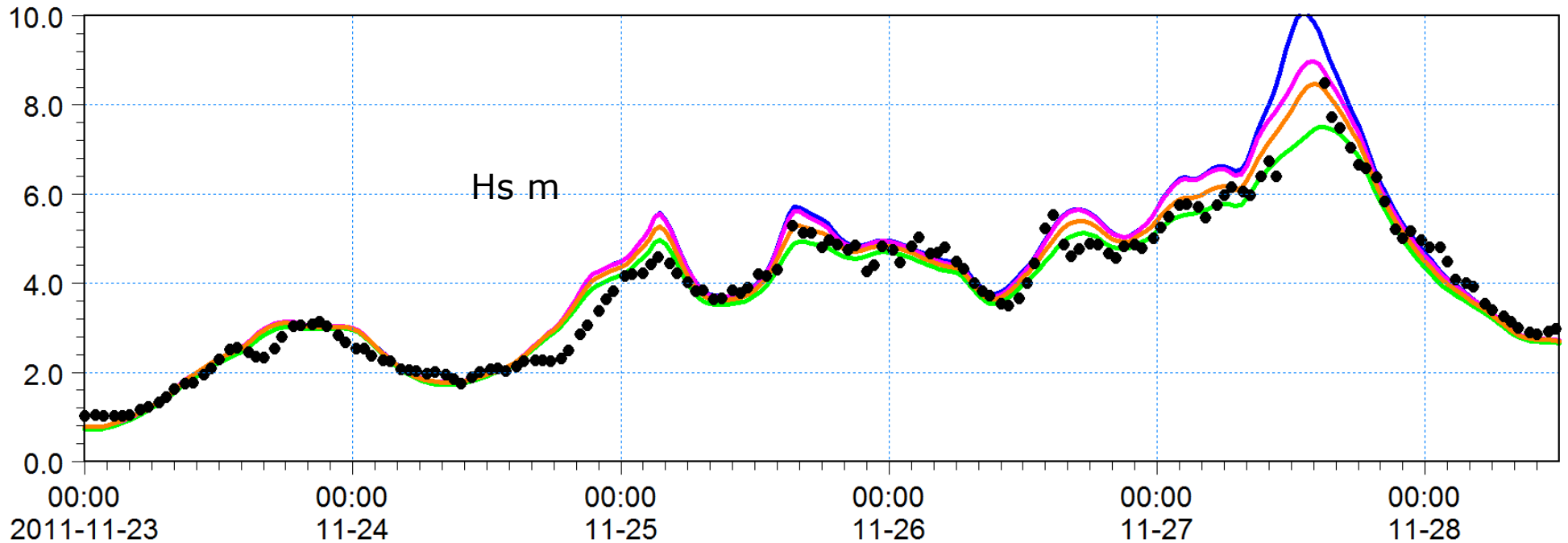
We have been examining the coastal, storm, issues, including
model resolution, input data, fetch effect



We have been examining the air-sea interaction physics

Actions

Standard	[m]	—
Fan (2012)	[m]	—
Cap 0.055	[m]	—
Reduced growth	[m]	—
Measured Hm0, Ekofisk	[m]	• •



- Oost et al(2002) $z_0 = \frac{50}{2\pi} L_p \left(\frac{u_*}{c_p} \right)^{4.5} \sqrt{1 - \frac{\epsilon_w}{\tau}} + \frac{0.11\nu}{u_*}$
- Taylor and Yelland(2001) $z_0 = 1200 h_{m0} \left(\frac{h_{m0}}{L_p} \right)^{4.5} + \frac{0.11\nu}{u_*}$

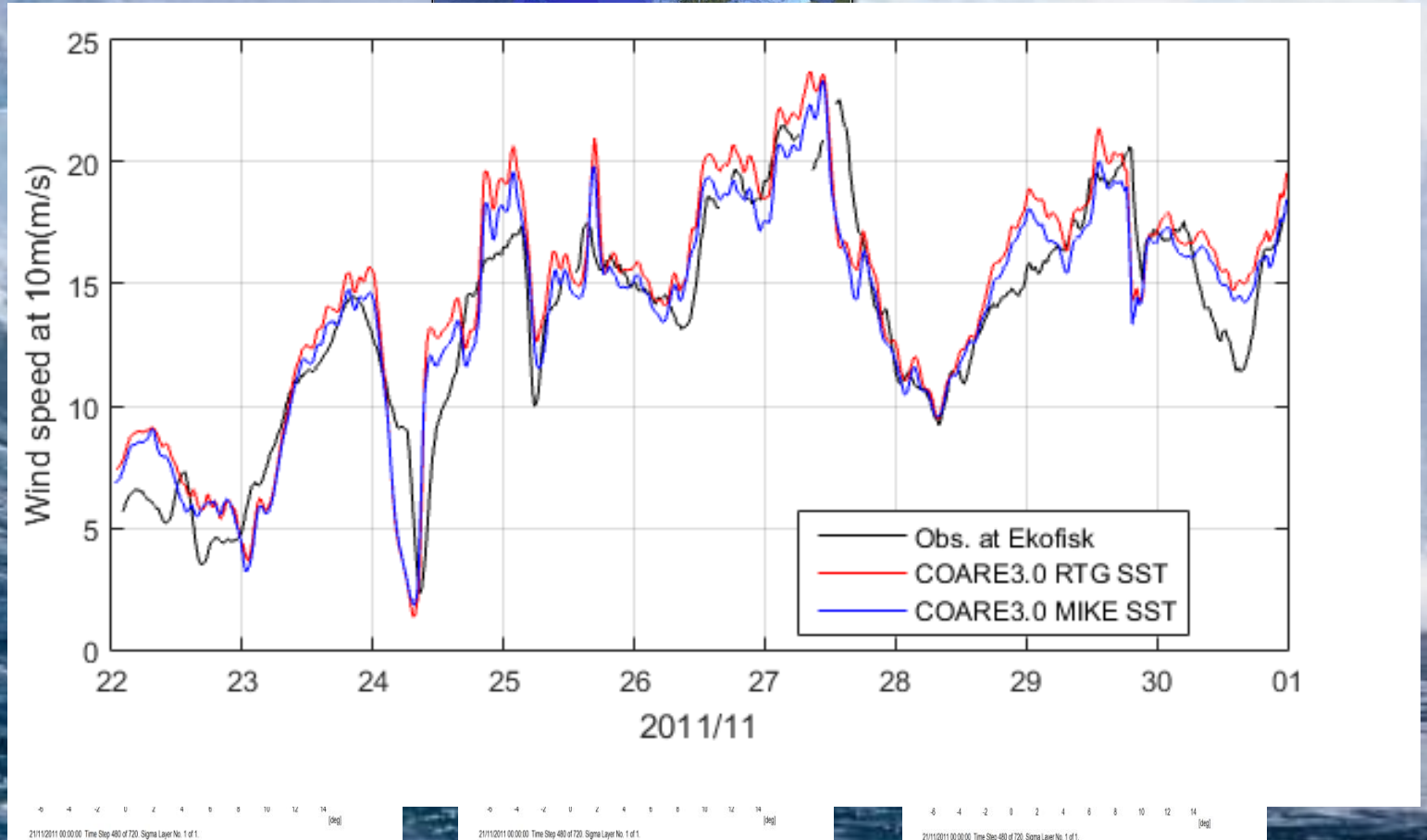
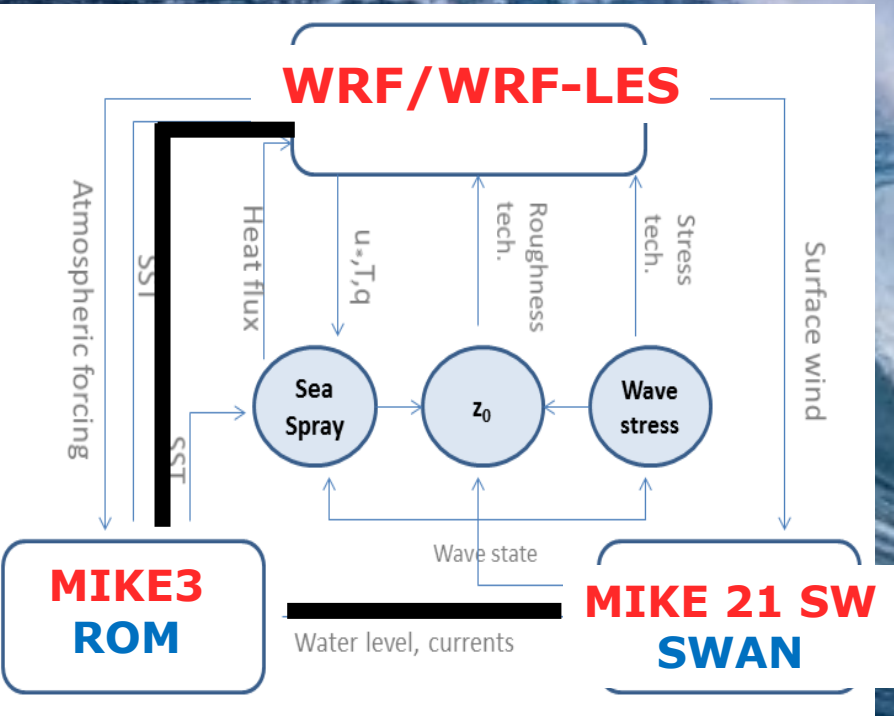
We have been examining the oceanic impact

Actions

Including **SST**, **current** and water level



MIKE 3 Model domain



Surface current

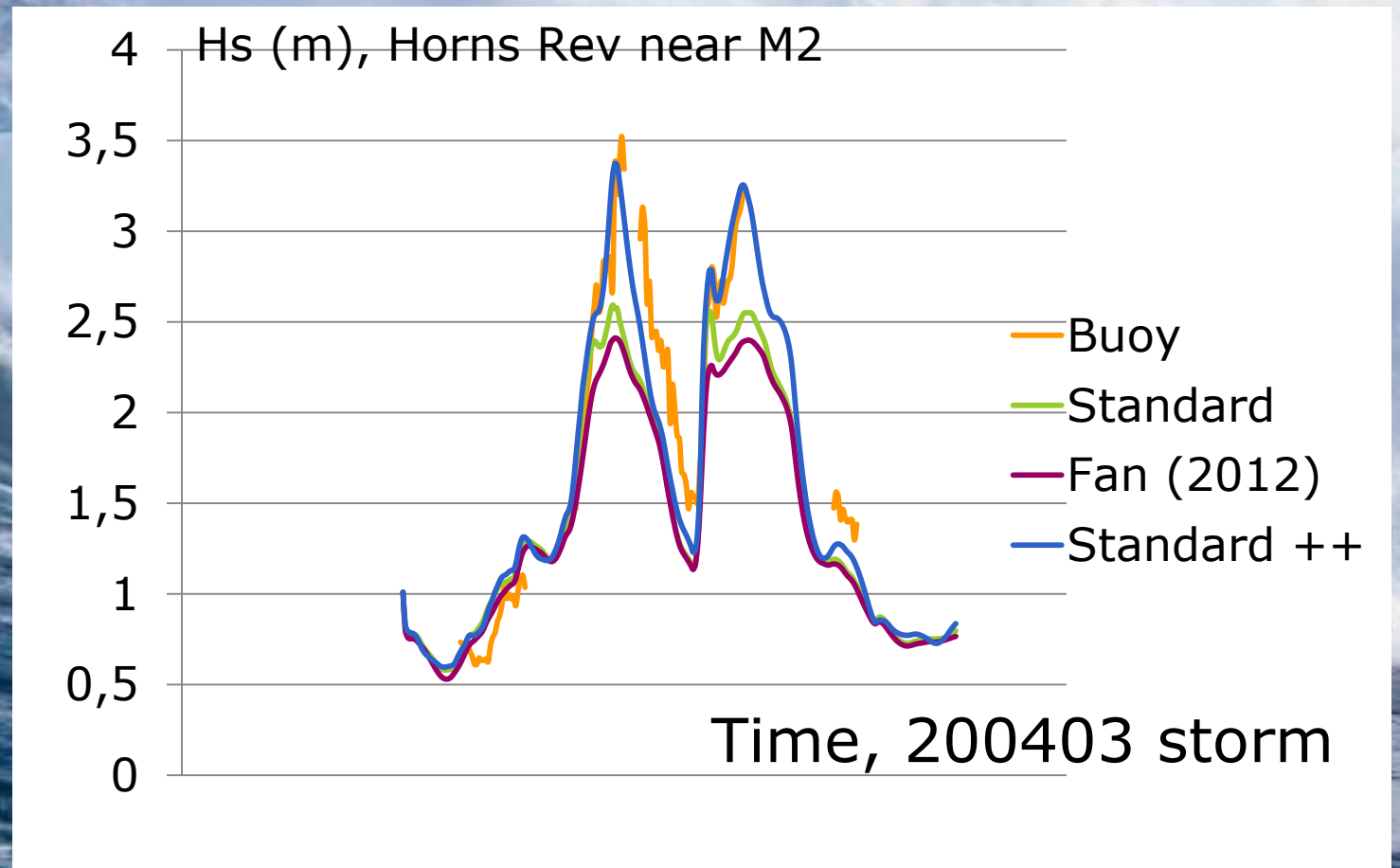
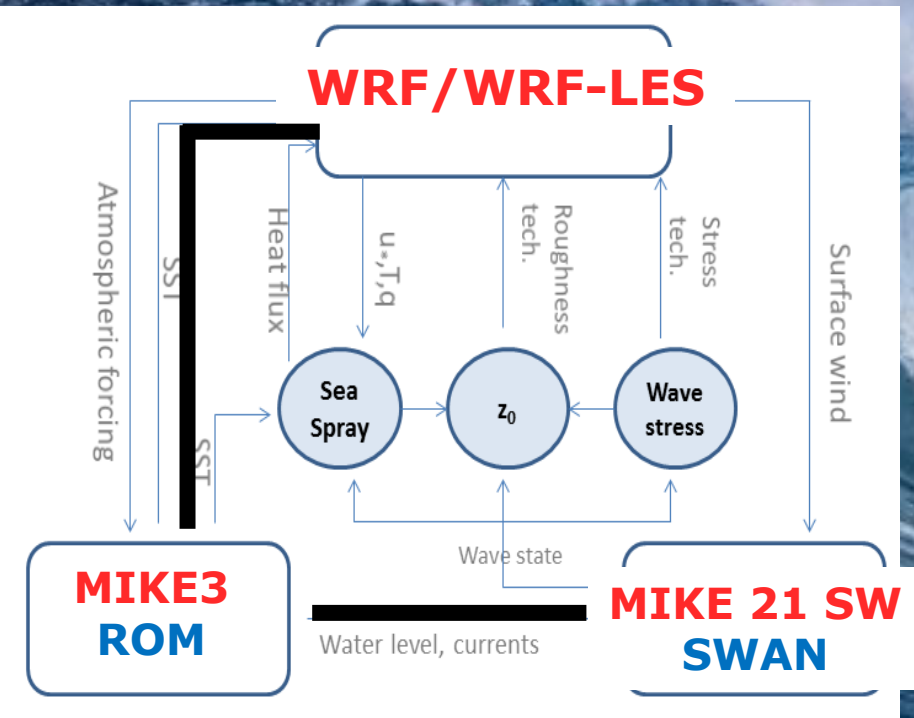
Sanility

SST

Actions

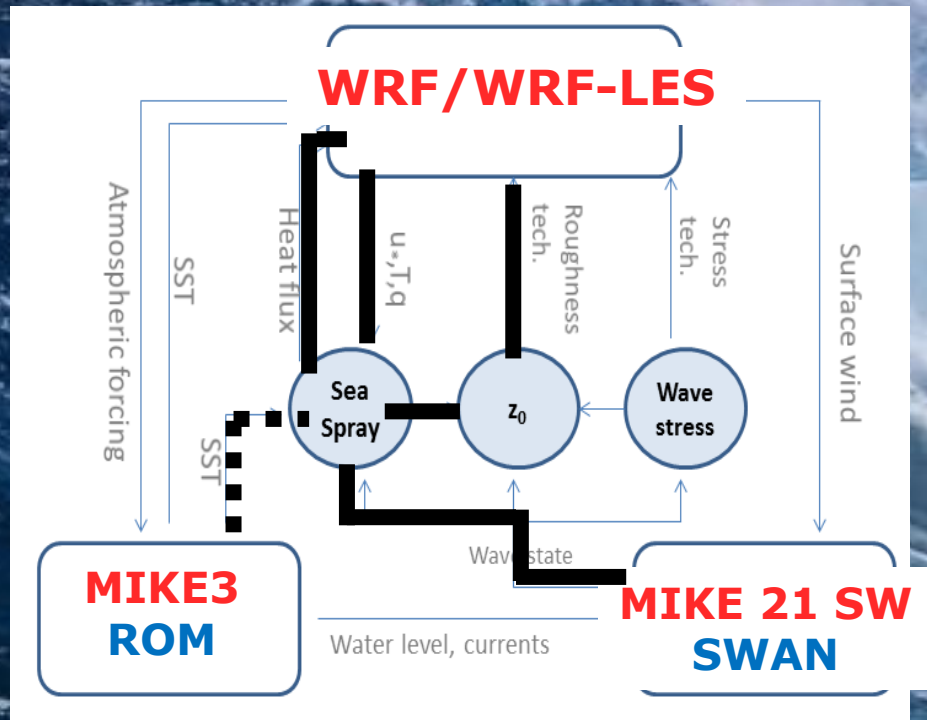
We have been examining the oceanic impact

Including SST, current and **water level**



We are examining the Spray effect...

Actions



Actions - Validation

Mean meteorological measurements

Turbulence

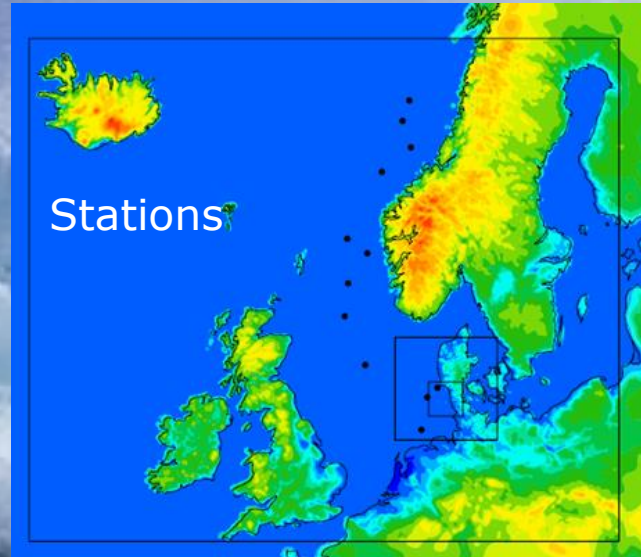
Mean wave data

Cloud pictures

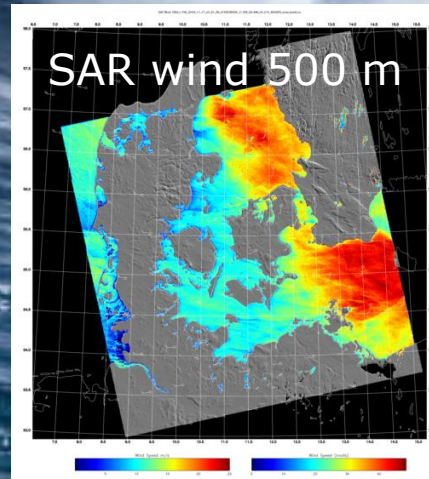
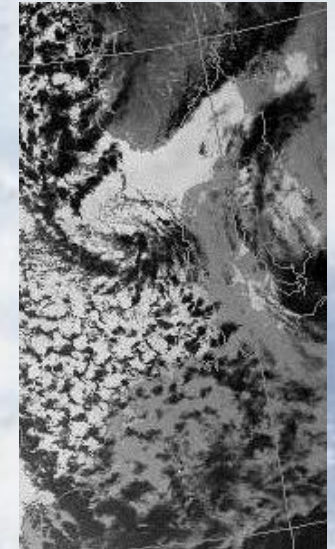
QuikSkat (wind, temperature, Hs)

SAR wind

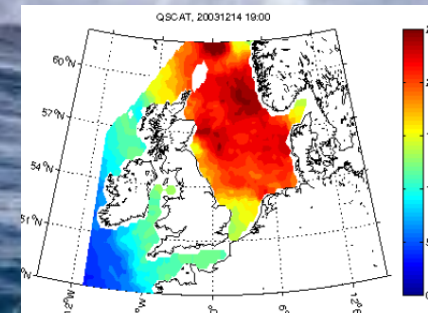
We have been validating the model results through
various kinds of measurements



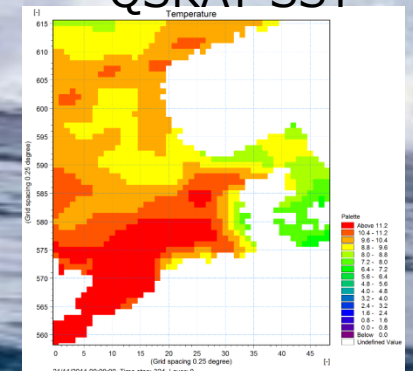
Cloud Picture



QSKAT wind, 25 km



QSKAT SST



Action - Validation

We have been **validating** the model results through various kinds of measurements in many ways

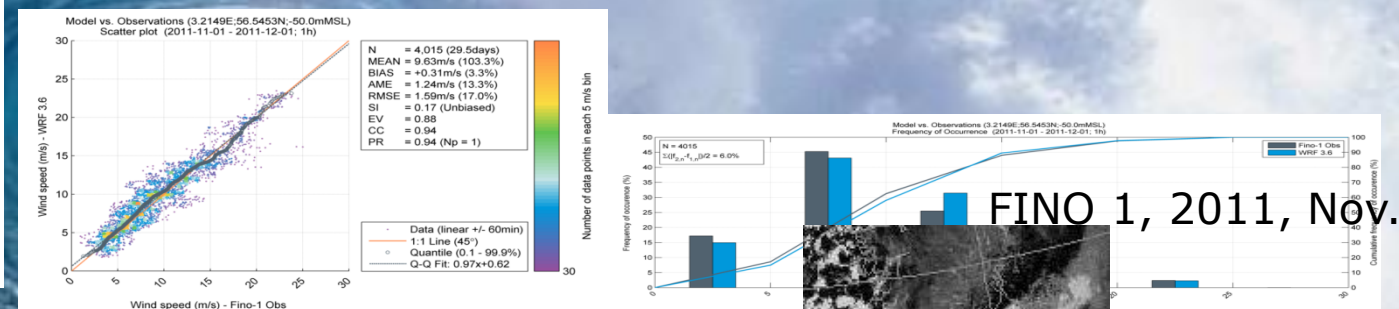
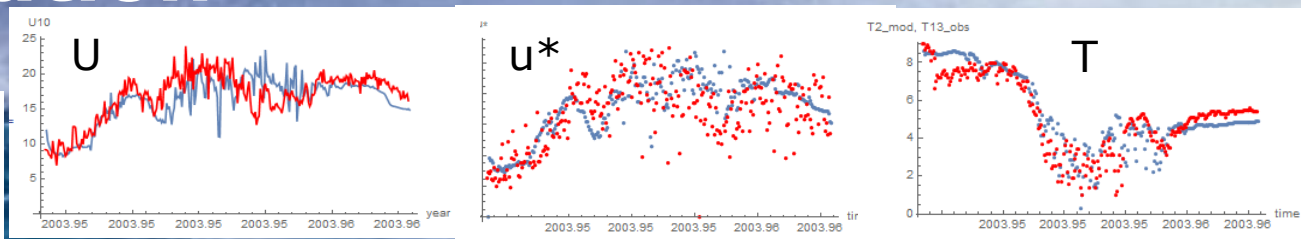
Time series

Distribution

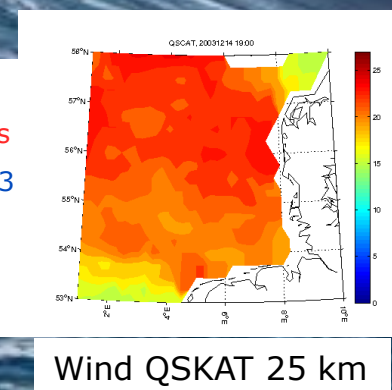
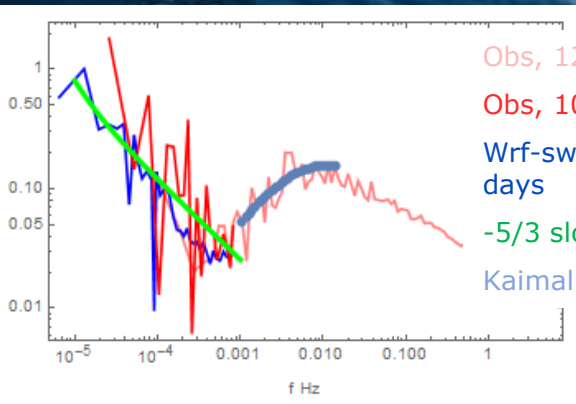
Spatial distribution

Spectral analysis

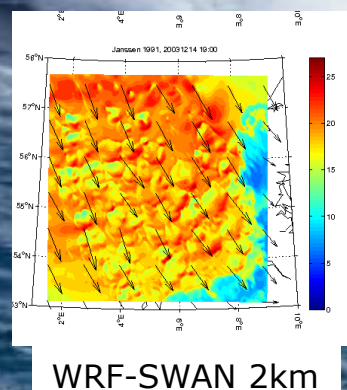
Compared to literatures



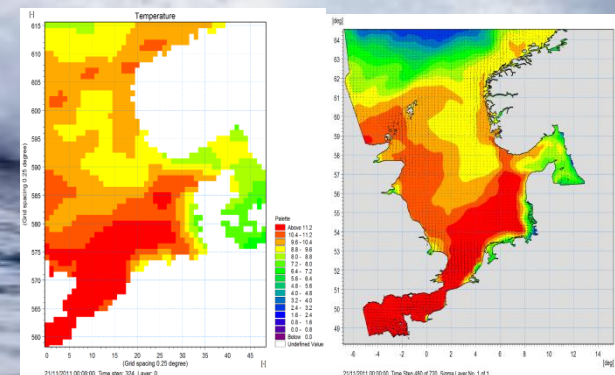
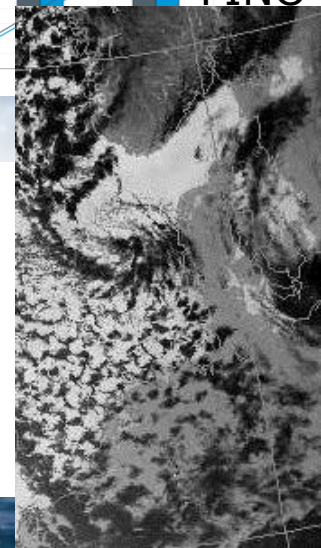
FINO 1, 2011, Nov.



Wind QSKAT 25 km



WRF-SWAN 2km



Satellite SST, MIKE 3 SST
NOAA radiometers

What we can offer

- Wind and wave data in the coastal zones
 - high resolution
 - from advanced modeling
 - Long term statistics vs time series
 - For siting, design, O&M
- Tools
 - A modeling system, particularly for storm conditions, suitable for coastal zones
 - Post-processing program for assessing, evaluating and applying the data for particular use
- Improved knowledge, in technology, science and application

Final remarks

- Better understanding and modelling of the challenging conditions: Storms, coastal zone
- Targeted at issues relevant for offshore (open sea and coastal) applications
- Useful input for existing systems